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TECHNICAL SPECIFICATION

SEL 86-1

SPACE ENVIRONMENT MONITOR

FOR THE NOAA SATELLITES

NOAA-K, NOAA-L, NOAA-M

1987 February 9

SPACE ENVIRONMENT LABORATORY
NATIONAL OCEANIC AND ATMOSPHERIC ADMINISTRATION
325 BROADWAY
BOULDER, COLORADO 80303

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Technical Specification
SEL 86-1

for the Space Environment Monitor

Approved:

2/9/87

David S. Evans — date

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William P. Barrett — date

9 Feb 87

Herbert H. Sauer — date

Feb 9 1987

Lorne D. Matheson — date

1987 Feb 9

Robert H. Bushnell — date

Technical Advisory Committee
to the
Source Selection Advisory Committee
for the
Space Environment Monitor
on the
NOAA-K, NOAA-L, NOAA-M
Satellites

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TECHNICAL SPECIFICATION FOR THE SPACE ENVIRONMENT MONITOR FOR THE NOAA K, L, AND M SATELLITES

1.0 SCOPE

This specification specifies the performance, fabrication, calibration and testing required of the Space Environment Monitor (SEM) to be flown as a subsystem on the NOAA-K, L, and M spacecraft. The SEM is a TIROS instrument. NOAA-K, L, and M will fly in the 1990-1995 period. The spacecraft will be essentially similar to the previous NOAA spacecraft in this series which have carried SEMs having nominally similar performance to that required by this specification.

The SEM is required to meet the General Instrument Interface Specification (ref. 2.4) and to operate with minimal changes to the software used on the ground.

1.1 Nature of the Monitor (for information only)

a. Within the last twenty-five (25) years, significant advances have been made in the understanding of the space environment of the earth, its relationship to solar activity, and the consequences of such activity of importance to man. The earth has been found to be immersed in an ionized plasma termed the solar wind, consisting of predominantly low energy charged particles continually emitted from the sun. This solar wind provides the energy for the containment of the earth's magnetic field in the magnetosphere, provides the particle source for the population of the earth's radiation belts and particle precipitation phenomena and ultimately provides an energy input determining the dynamic state of the earth's atmosphere and ionosphere.

b. It has also been recognized that in addition to the quiescent solar wind, there occur rather impulsive changes in the solar wind as well as the emission of energetic (1-1000 MeV) protons and alpha particles by the sun. These are fairly common occurrences, particularly near the peak of the solar activity cycle. These phenomena, in addition their intrinsic scientific interest, can have important practical consequences. Changes in the energy input to the atmosphere and ionosphere can produce significant disturbances of the atmospheric heat balance and the ionospheric electron density profiles producing disturbances of normal communication modes in the ionosphere. Energetic solar proton events pose a calculable radiation hazard to manned space flight activities as well as to high altitude aircraft flights, and give rise to intense, long duration radio blackouts at high latitudes.

c. The Space Environment Monitor (SEM) makes measurements of the energy spectrum and directional distribution of charged particle fluxes in the vicinity of the spacecraft and formats the data appropriately for interfacing with the spacecraft telemeter. The energy range covered is from 50 eV to more than 140 MeV. Because of the differences in sensor technology required to cover this range and the different applications of the data, the SEM is divided into two separate and distinct instruments: first, a Total Energy Detector (TED) which measures the flux of charged particles precipitating into the atmosphere in the range 0.05 to 20 keV; and second, a Medium Energy Proton and Electron Detector (MEPED) spanning 30 keV to more than 140 MeV measuring both the geomagnetically trapped and solar cosmic ray event particles.

d. The existing SEMs are based on the use of electrostatic analyzers and channeltron detectors for the TED and silicon particle detectors for the MEPED. The TED and MEPED carry out analog amplification, filtering, and level detection to bring the signals corresponding to individual particle events to a common logic level interface. Some combinational logic and accumulation (counting) of events in the desired categories are carried out in a central Data Processing Unit (DPU). The DPU also serves to form a common interface between the SEM and the spacecraft.

1.2 Total Energy Detector TED

Background to the Technical Requirements (for information only).

a. At high geographic latitudes a major source of energy input into the atmosphere above 95 km is from the magnetosphere in the form of charged particle precipitation and joule heating by ionospheric current flow which is driven by magnetospheric processes. At high latitudes this heat input can dominate that due to solar electromagnetic radiation, even during the arctic summer.

b. The particle energy flux is carried by both positively charged ions (primarily protons but heavier ions may participate) and electrons. Negative ion fluxes are an insignificant contributor to the precipitation. The TED is required to monitor this source of heat input into the atmosphere and to distinguish between electrons and ions because the two particle types deposit their energy at different altitudes. The minimum relevant particle energy is 0.05 keV. Even modest fluxes of such low energy particles can have important effects because the energy is deposited into a region of very low air density. An upper limit of 20 keV for the particle energy is chosen because it is rare that still higher energy particles are significant contributors to the energy flux. A separation of the energy flux carried by particles of energy less than 1.0 keV from that carried by those of energy greater than 1.0 keV is required because of the important differences in the effects upon the atmosphere of these two energy ranges.

c. The prime purpose of the TED is to provide the information needed to obtain a measure of F_T, the energy flux into the atmosphere carried in the form of charged particles. At the altitude of NOAA-K (ref. 5.1 a.) the relevant particles are those with pitch angles alpha less than alpha_{max}.

F_T is defined as:

$$F_T = 2\pi \int_0^{\text{alpha}_{max}} \sin\alpha \cos\alpha \int_{0.05}^{20} j(E,\text{alpha})\, E\, dE\, d\alpha$$

j(E,alpha) is the differential directional particle number flux in terms of number/(cm^2.sr.unit energy); E is the particle energy in keV; alpha is the particle pitch angle; $alpha_{max}$ is the half-width of the loss cone. The TED is to do the integral over energy E and telemeter this value F(alpha) to the ground where the integration over angle alpha will be done. The angles will be obtained from the satellite orbital data and need not be measured.

d. A measure of the peak flux value in the particle spectrum and the particle energy at which this occurs are required in order to estimate the altitude in the atmosphere at which these particles deposit their energy.

e. Crude particle energy spectrums (particle intensities for at least 4 energies spaced over the range between 0.05 keV to 20.0 keV) from all detectors are required (at a sampling frequency permitted by the telemeter). These data will permit checking of the determination of the integrated particle flux over this energy range, assist in malfunction identification, and provide details of the particle precipitation not otherwise available.

f. At the latitudes of interest (above 35 degrees geographic), the magnetic field geometry is such that at 800 km altitude all particles moving downwards within 45 degrees of the local magnetic field are in the loss cone and deposit almost all their energy into the atmosphere. Observations of the energy flux carried by particles exiting upwards from the atmosphere are not required as this flux is normally 15% of the flux entering the atmosphere and represents a small correction to the observation of downward flux.

g. In order to measure particles within the atmospheric loss cone over geographic latitudes of interest and to account for anisotropic angular distributions in the precipitating particles, two separate, narrow angle, measurements are to be made, one at 0 degrees to the earth centered radial vector (viewing upwards) and the other at 30 degrees. At geographic latitudes of interest, both these angles view particles within the atmospheric loss cone and permit a two (2) point angular integration to be made to determine the net energy flux into the atmosphere below the satellite.

h. It is recommended that the TED design be based on the use of a swept electrostatic analyzer and channeltron detector system. Alternative mechanizations may be proposed.

1.3 Medium Energy Proton and Electron Detector MEPED

Background to the Technical Requirements (for information only).

a. The MEPED is required to measure the particle radiation environment, consisting of particles with energies higher than those measured by the TED, along the satellite orbit. At low to middle latitudes, this environment consists primarily of energetic particles temporarily trapped in or precipitating from the earth's radiation belts. At higher latitudes, the energetic particles encountered by the satellite are primarily of galactic or solar origin, and have direct access from the interplanetary medium to the polar caps of the earth. The energies to be measured range from 30 keV to more than 140 MeV. The components of the energetic particles 1) magnetically mirroring below the satellite or 2) precipitating into the earth's atmosphere, are to be nominally separated at high latitudes by making measurements along and perpendicular to the local zenithal direction. Four (4) higher energy detectors are to make nominally omnidirectional measurements of energetic protons (ions) in the hemisphere above the satellite. To preserve continuity, it is desired that the directional sensors be nominally identical and the omnidirectional sensors be similar to those which have been flown on the TIROS-N satellites.

b. It is recommended that the MEPED measurements be performed with solid state detectors in conjunction with electronic pulse height analysis techniques. Nominal systems are:

c. Directional Measurements:

1. Protons and Heavier Ions

A pair of solid state detectors arranged in a telescope configuration with a "broom" magnet positioned in front of the telescope.

2. Electrons

A single solid state detector with a thin metallic foil used as a combination low energy proton and light shield.

d. Omnidirectional Measurements

Four (4) channels using detectors similar to those previously used in the TIROS-N series.

1.4 Data Processing Unit DPU

Background to the Technical Requirements (for information only).

a. In concept, the DPU contains most of the digital logic required to gate and accumulate particle counts and provides the common interface with the spacecraft telemeter. If a sensor with an analog output is used for a data channel, then a suitable analog-to-digital converter is required to interface with the Spacecraft Digital "A" circuit and meet the accuracy and resolution requirements. The DPU also concentrates and distributes the SEM interface with the spacecraft command and power systems.

b. The TIROS Information Processor (TIP) provides the interface between the low data rate instruments, including the SEM, and the spacecraft tape recorders and transmitters. In the mission mode format of the TIP, data are arranged into 0.1 second duration minor frames containing one hundred four (104) 8-bit words (8.32 k bits/s). The SEM currently is assigned two (2) of these words in this Digital "A" format for an effective data rate of 160 bits per second. The DPU accumulates data, stores, and develops the format put out to the TIP.

c. Separately available to the SEM are individual lines for analog housekeeping (Analog) and discrete (on/off) indicators (Digital "B"). These are assembled by the TIP into the spacecraft housekeeping telemetry. To avoid having to merge the SEM format and the spacecraft format on the ground, the SEM analog and discrete variables shall also be included within the SEM Digital "A" format.

d. To show the status of the SEM when its main power is off, Analog and Digital "B" are powered separately from the data circuit (Digital "A").

e. Compression type accumulators (counters) are required which provide a quasilogarithmic response, maintain an approximately constant LSB error percentage and minimize the telemetry requirements. All channels with count rate outputs are required either to have independent accumulators and operate at close to 100% accumulation efficiency or to share not more than two channels in one accumulator for a 50% efficiency. Taking into account the maximum flux and counting rates required of the MEPED, a 19-bit accumulator is required. The data from this can be compressed into 8-bits while still preserving reasonable accuracy. If the TED is implemented with event counting techniques, then an identical or similar accumulator for the TED would be compatible with its resolution requirements.

1.5 Differences (for information only)

Some features of the SEMs specified here differ from those of previous SEMs.

The TED measures to a lower energy, 0.05 keV.

The TED integral F(alpha) has two (2) ranges, 0.05 to 1 and 1 to 20 keV.

Particle accelerator calibration is required on each TED.

The MEPED has a fourth omnidirectional proton measure, 140 MeV.

The ion signal is deleted.

There is only one data telemetry mode.

More data are telemetered.

All commanded states are routinely telemetered.

The HEPAD which was included in previous SEM's is no longer required. Telemetry allocations for the HEPAD are available for further assignment.

This list is not necessarily complete.

Note that the present TIROS-N Unique Interface Specification referenced for information is applicable in detail only to the prior instruments. A new unique specification will be generated for the instruments resulting from procurements to this specification.

2.0 APPLICABLE DOCUMENTS

The documents identified below shall control the design and production work to be conducted in accordance with this specification. The documents form part of this specification to the extent and manner described herein and are made a part hereof by reference.

2.1 Revisions

When the applicable documents are revised, the SEM contractor is encouraged to follow, and to authorize his subcontractors to follow, the applicable portions of the revised publication. However, the contractor is not required to comply with revisions made after the award date of the contract except as a contract change.

2.2 Military Standards and Specifications

DOD-STD-100C Engineering Drawing Practices 4 May 83

MIL-STD-130F Identification Marking of U.S. Military Property 2 Jul 84

2.3 NASA Documents

GSFC-S-480-16B Performance Specification for the NOAA-H through -J Satellites September 1985

GHB 7120.1, August 1971 - Handbook for Preparation and Implementation of Work Breakdown Structures

SP208 - The Prevention of Electrical Breakdown in Spacecraft 1969

2.4 Other Documents

SEL Specification 86-2, Performance Assurance Requirements for the Space Environment Monitor (SEM), 1986 Dec 10

RCA Specification IS-2280259, Revision V dated 12-11-85, TIROS-N General Instrument Interface Specification.
Hereafter called GIIS.
It is emphasized that the GIIS shall be followed.

USA Standard, Drafting Practices, USASI Y14.5M-82, Dimensioning and Tolerancing of Engineering Drawings.

The following document, not part of this specification, is listed only for information about the existing SEM design:

RCA Specification IS-2280264, Revision E dated 5-29-85, TIROS-N Unique Interface Specification for the Space Environment Monitor

3.0 TECHNICAL REQUIREMENTS

3.1 Total Energy Detector TED

3.1.1 Particle Species and Energy Range

a. The TED shall provide measures related to j(E,alpha), the differential directional particle number flux of either electrons or protons in units of number/(cm^2.sr.keV). E is particle energy in keV, alpha is the pitch angle of the particle. For protons the measures may include alpha particles and positive ions. The following list assumes that an analyzer sweeps over the energy range. The TED shall provide separate values for electrons and protons of the following measures:

TED item 1. The directional energy flux F(alpha), defined as

$$F(\text{alpha}) = \int_{0.05}^{20} j(E,\text{alpha})\, E\, dE$$

For TED Item 1. the limits of the integration over energy E are 1.0 keV and 20 keV.

TED item 2. A partial value of F(alpha), the flux integral from 0.05 keV to 1.0 keV.

TED item 3. The maximum value of j(E,alpha)E within each energy sweep.

TED item 4. The energy E at which the maximum in TED item 3. occurred.

TED item 5. Either particle number flux or differential energy flux for at least four (4) separate energies E during an energy sweep.

TED item 6. Sensor background (response during periods when no particle excitation is allowed) for each individual sensor to assist in correcting for spurious sensor response and checking instrument operation.

b. These measurements may be performed in the following manner. The energy range 0.05 keV to 20 keV may be divided into energy bands. The bandwidths DE_i may be constant or proportional but shall not exceed 60% of the center energy E_i. The variable

$$\overline{(j(E,\text{alpha})E)_i} = \frac{1}{DE_i} \int_{E_L}^{E_u} j(E,\text{alpha})\, E\, dE$$

is a satisfactory measure of j(E,alpha)E for the band E_i. A

measure of the maximum value of $\overline{(j(E,\text{alpha})E)_i}$ as well as E_i are to be transmitted once each sweep for each of the two angles and two particle species. This definition of differential flux and the acceptable means of measuring that flux apply also to the measurements of flux within the four (4) energy bands during a sweep.

c. Section 1.2 h. suggests the use of electrostatic analyzers and particle counters as the TED instrument. However, alternative devices (such as scintillators, CdS detectors, etc.) which may have advantages in simplicity, dynamic range, sensitivity, and the like will be considered.

d. The specification herein refers to the use of a detector system which is differential in both energy and angle (i.e., an electrostatic analyzer/particle counter) which sweeps over the energy range. If an alternative system is used, the design must include an analogous set of performance specifications and definitions including a comparison with the specification here.

3.1.2 Dynamic Range and Accuracy

3 1.2.1 Electrons

a. The directional energy flux F(alpha) to be measured ranges from <= 0.01 erg/(cm^2.s.sr) to >= 100 erg/(cm^2.s.sr). Over this range, the resolution with which this flux is measured shall be better than ± 15% for fluxes <= 0.06 erg/(cm^2.s.sr) and better than ± 5% for fluxes >= 0.06 erg/(cm^2.s.sr). The integration time necessary for the determination of directional energy flux values of <= 0.1 erg/(cm^2.s.sr) shall be <= 10 s. The integration time for energy fluxes >= 0.1 erg/cm^2.s.sr) shall be <= 1 s.

b. The resolution in the measurement of j(E,alpha)E shall be better than ±15% for values < 3 x 10^{-3} erg/(cm^2.s.sr.keV) and better than ± 5% for greater values.

3.1.2.2 Protons

a. The directional energy flux F(alpha) to be measured will range from <= 0.01 erg/(cm^2.s.sr.) to >= 32 erg/(cm^2.s.sr). Over this range, the resolution with which this flux is measured shall be better than ± 15% for fluxes <= 0.06 erg/(cm^2.s.sr) and better than ± 5% for fluxes >= 0.06 erg/(cm^2.s.sr). The integration time necessary for the determination of directional energy fluxes of <= 0.1 erg/(cm^2.s.sr) shall be <= 10 s. The integration time for energy fluxes >= 0.1 erg/(cm^2.s.sr) shall be <= 1 s. (Amend 1 B. 5.)

b. The resolution in the measurement of j(E,alpha)E shall be better than ± 15% for values less than 3 x 10^{-3} erg/(cm^2.s.sr.keV) and better than ± 5% for greater values.

3.1.2.3 Accuracy

The TED shall be capable of an absolute accuracy of better than ±50%. This shall be demonstrated, by analysis, reference to published results or measurement.

3.1.2.4 Resolution

As used above, the word "resolution" is used in the sense of quantization intervals or minimum detectable flux variations and is not intended to be synonomous with "accuracy". However, in determining performance levels of resolution and accuracy, the effect of telemetry encoding shall be included.

3.1.3 Field of View

Two (2) independent measurements of the required particle fluxes shall be made in directions centered at 0 degrees and at 30 degrees to the spacecraft -x axis (local vertical away from the earth.) The field of view of each shall not exceed a maximum of 15 degrees full angle.

3.1.4 Sampling Rate

a. One (1) complete set of the data for the energy fluxes F(alpha) (TED items 1. and 2.), the maximum (TED item 3.) and energy E (TED item 4.), for the two particle species and the two (2) directions shall be sampled and telemetered at a rate >= one sample in 2 seconds.

b. The data for TED item 5., the four (4) point spectrum numbers, may be provided at a lower rate than the measures in TED items 1., 2. and 3. Four (4) point energy spectra shall be made available from individual electron energy sweeps (for two (2) look angles) no less often than every 8 seconds. Four (4) point energy spectra shall be made available from individual proton energy sweeps (for two (2) look angles) no less often than 3 times in any 32 seconds. (Amend 3)

c. The sampling rate for TED item 6., the background from each detector, shall be no less often than every 32 seconds.

d. The determination of energy fluxes of <= 0.1 ergs/(cm^2.s.sr) to the required resolution may be made in ground processing by averaging the telemetered data from up to five consecutive, common species, sweeps.

e. It is assumed, but not required, that an electrostatic analyzer will be used to select particle species and energy and that the analyzer will alternate between species. As simultaneous measurements of each species are not required, a full data set can be obtained within <= 2 seconds by utilizing an integration time of <= 1 second per species.

3.1.5 Spurious Responses

3.1.5.1 Light (Sunlight and Moonlight)

Experience has shown that existing TEDs respond to sunlight. For this reason we require the following:

The TED response to sunlight shall not exceed 0.01 erg/(cm^2.s.sr) equivalent energy flux under all normal spacecraft operating sun gamma angles (0-80 degrees) (ref PAR Appendix E 3.4) and under worst case conditions. The response to moonlight shall not exceed 0.10 erg/(cm^2.s.sr) under normal spacecraft operating conditions and worse case moon angle and phase. The moon is allowed a higher value here because the orbits of NOAA-K and the moon produce less exposure. A desirable design target is for these responses not to exceed one tenth of the these values.

3.1.5.2 Particle Cross Talk

A full scale response in any proton or electron channel shall result in a spurious response in any other channel of <= 0.032 ergs/(cm^2.s.sr).

3.1.5.3 High Energy Particles

An energy flux of 60 erg/(cm^2.s.sr) carried by particles with energies greater than 30 keV, shall not cause a response > 0.6 erg/(cm^2.s.sr).

3.1.5.4 Multiply Charged Positive Ions

The TED is not required to separate ions as to charge state nor to distinguish them from protons.

3.1.5.5 Electrical Interference

The TED must not respond to electrical interference, including ripple on the SEM power supplies, at any time in the period specified in 5.5.

3.1.5.6 Surface Charge

No material or surface shall be present near the charged particle sensors in the TED that could acquire an electrical charge or emit particles by virtue of acquiring such a charge (field emmision). Materials and surfaces should not degrade with time so as to permit such a condition to come about with age.

3.1.6 Worst Case Energy Spectrum

Often instrument design involves instantaneous count rate limitations or other nonlinearities which may set constraints upon the measurements. In such cases, compliance with the specifications for these measurements will be accepted if the TED can be shown to perform within specifications in a worst case environment which results in a maximum energy flux of 100 erg/(cm^2.s.sr) (electrons) or 32 erg/(cm^2.s.sr) (positive ions) in which 50% of the energy flux is carried by particles having kinetic energies within a 3 keV bandwidth anywhere within the TED energy range.

3.1.7 In-Flight Calibration (TED IFC)

a. An automatic, in-flight calibration system or method, started by command, shall be provided capable of tracking changes in the TED electronic (i.e., excepting detectors) sensitivity to $\pm$ 7.5% accuracy during the orbital lifetime of the TED.

b. TED IFC shall terminate automatically as well as terminate on "Terminate IFC" command.

c. Whenever TED IFC terminates, whether automatically or by "Terminate IFC" command, all settings, for example, threshold levels, which change or may change during TED IFC shall return automatically to the settings before the IFC started.

3.1.8 Stability

When exposed to a constant energy flux of any value within the operating range of the TED, the indicated flux shall not vary more than 5% over the mission allowable temperature range (PAR 3.6.2.1 e.) and normal supply voltage range.

3.1.9 Lifetime

The design shall show that the sensor design selected will perform within specification during its first two (2) years in orbit. Under the combined effects of the spacecraft radiation environment specified in section 5.4 and a continuous energy flux in the operating energy range of 10 erg/(cm^2.s.sr), sensitivity shall not drop by more than 50% in two (2) years. Automatic or commandable sensitivity correction, based on the in-flight calibration data, may be used to meet this requirement if needed. (ref. 5.5)

3.1.10 Housekeeping Telemetry

Housekeeping telemetry outputs from the TED shall be provided through the DPU to both Digital "A" and Analog. These shall be sufficient to monitor the status of the TED. They shall include, but are not necessarily limited to:

a. Critical temperatures
b. Detector voltages
c. Critical circuit voltages
d. Status of commanded and controlled circuits.

3.1.11 Size and Mass

a. The outside dimensions of the TED shall not exceed 444 mm long, 154 mm wide and 173 mm high. A design goal is that these not exceed 394 mm long and 148 mm high.

b. The mass of the TED shall not exceed 4608 g. A design goal is that the mass not exceed 3293 g.

3.1.12 Physical Spacing

The input/output circuits of the TED shall be capable of operation with 4600 mm (15 feet) of separation between the TED and the DPU.

3.1.13 Thermal Requirements

The design shall specify any special operating thermal requirements; e.g., special detector limitations, recommended operating ranges, etc.

3.1.14 High Voltage Protection

If voltages in excess of 100 V are used, the design shall show how the TED will be internally designed and constructed to protect the TED itself, the interface with the DPU, and the interface with the rest of the spacecraft from damage due to the effects of possible high voltage breakdown.

3.2 Medium Energy Proton and Electron Detector MEPED

3.2.1 MEPED Directional Measurements

3.2.1.1 Energy Spectral Intervals

a. By using a discriminator-type (comparator-type) pulse height analyzer the MEPED shall provide independent measurements of the flux of particles of the types, and in the following energy spectral intervals:

Particle	Energy Interval
1. Protons	30 keV - 80 keV
	80 keV - 250 keV
	250 keV - 800 keV
	800 keV - 2500 keV
	2500 keV - 7000 keV
	>= 7000 keV (integral channel)
2. Electrons	>= 30 keV (integral channel)
	>= 100 keV " "
	>= 300 keV " "

b. The spectral intervals are nominal and may be adjusted by up to $\pm 20\%$ provided the design shows the advantages of the adjustment. However, the lowest range for both protons and electrons shall start at 30 keV or less.

3.2.1.2 Directional Responses

3.2.1.2.1 Number of Measurements

In the spectral intervals listed in 3.2.1.1, two (2) independent measurements of the flux are required; one parallel to the spacecraft -x axis (local vertical away from earth) and the second perpendicular to it.

3.2.1.2.2 Directional Response and Geometric Factor

The full angle directional response shall be limited to <= 30 degrees. The geometric factor of each detector shall be approximately 10^{-2} cm^2.sr.

3.2.1.3 Noise

The Full Width Half Maximum (FWHM) pulse height spectrum response to an electronic pulse equivalent to that produced by a monoenergetic particle source shall be <= 7 keV equivalent particle energy response.

3.2.1.4 Spurious Count Rate

The spurious count rate, due to noise or interference reaching the pulse height analyzer, shall be less than one (1) count in ten (10) seconds in any channel.

3.2.1.5 Maximum Flux

The MEPED shall be able to measure a maximum flux of at least 5×10^7 particles/($cm^2 \cdot s \cdot sr$) of energy greater than the lowest energy threshold. It is a design goal that the output shall not decrease as the flux increases up to three (3) times the maximum flux listed above. When driven at rates from the maximum flux listed above up to ten (10) times that value the output of the MEPED shall not represent a flux less than 4×10^7 particles/($cm^2 \cdot s \cdot sr$), that is, the output in the range zero to 4×10^7 shall not be double valued.

3.2.1.6 Measurement Rate

A complete set of measurements in all energy channels, in both directions, and for both electrons and protons shall be made at least once in each two (2) second period with an accumulation efficiency of > 49%.

3.2.1.7 Shielding

Away from the collimator openings, shielding of the sensor assemblies shall be sufficient to stop <= 90 MeV protons and <= 6 MeV electrons. The shielding shall be designed to minimize the effects of bremsstrahlung.

3.2.1.8 Spurious Response

3.2.1.8.1 Proton Response

a. The electron sensor shall not respond to protons of energy <= 150 keV or to protons whose energy loss within the detector is greater than the maximum possible energy loss for electrons.

b. The SEM contractor shall specify the residual proton energy sensitivity of the electron sensor (which shall be within the range of the proton sensor specified in 3.2.1.1) so that corrections may be made.

3.2.1.8.2 Electron Response

The proton and ion channels shall show no response to an electron flux entering the detector by the collimator, defined by $j(>E) = 2 \times 10^9 E^{-1.6}$ electrons/($cm^2 \cdot s \cdot sr$) where E is in keV. That is, the MEPED directional measurements shall operate properly in a trapped electron environment of integral flux of this value.

3.2.2 MEPED Omnidirectional Measurement of Protons

3.2.2.1 Energy Spectral Intervals

Four (4) channels are required with respective proton energy thresholds of >= 140 MeV, >= 70 MeV, >= 35 MeV, and >= 16 MeV. It is acceptable if the channels also respond to alpha particles.

3.2.2.2 Sensors

The sensors for these four (4) channels shall be functionally identical with those "omnidirectional detectors" previously flown on the TIROS-N spacecraft. Each sensor consists of a dome of moderating material, which sets the basic detection energy level, and a silicon detector or array of detectors. Together with an associated pre-amplifier and level comparator, which operates as a threshold circuit, the sensor responds essentially to all particles which can reach the detector through the moderator dome.

3.2.2.3 Noise

The FWHM pulse height spectrum response to an electronic pulse equivalent to that produced by a monoenergetic particle source shall be be <= 60 keV.

3.2.2.4 Measurement Rate

Measurements in the required energy ranges, with names identified in the SEM Digital A Telemeter Signals on page 49, shall be provided at least every two (2) seconds for P6 and P7 and at least every four (4) seconds for P8 and P9 with an accumulation efficiency of >= 99%. (Amend 3)

3.2.2.5 Electron Response

The four (4) channels shall show no response to an electron flux entering the sensor through the dome moderator of value defined in 3.2.1.8.2 .

3.2.3 Stability of Energy Thresholds

3.2.3.1 Temperature Coefficient of Electronic Thresholds

The temperature coefficient of the electronic thresholds shall be such that the total change in energy threshold shall be less than 5% over the qualification temperature range. (Ref PAR Appendix D)

3.2.3.2 Count Rate

As shown by test, the effective energy threshold shall not change by more than Y from the asymptotic, low-frequency value when responding to simulated events at the constant rates X.

X	Y
< 100 kHz	<= 5%
< 250 kHz	< 10%
< 500 kHz	< 20%

3.2.4 In-Flight Calibration (MEPED IFC)

The MEPED shall include an automatic, in-flight calibration system or method, started by command, capable of making electrical calibrations of the analog amplifier and pulse height analyzer portions of the MEPED through appropriate sequences of excitation. From the output of the MEPED during in-flight calibration, it shall be possible to obtain:

1. The energy of each threshold.

2. The total system FWHM noise for the directional channels to ± 0.5 keV.

a. This calibration shall be capable of tracking changes in the MEPED sensitivity to ± 7.5% accuracy during the orbital lifetime of the MEPED.

b. MEPED IFC shall terminate automatically as well as terminate on "Terminate IFC" command.

c. Whenever MEPED IFC terminates, whether automatically or by "Terminate IFC" command, all settings which change or may change during MEPED IFC shall return automatically to the settings before the IFC started.

3.2.5 Housekeeping Telemetry

Housekeeping telemetry outputs from the MEPED shall be provided through the DPU to both Digital "A" and Analog. These shall be sufficient to monitor the status of the MEPED. They shall include, but are not necessarily limited to:

1. Critical temperatures
2. Critical voltages
3. Status of commanded and controlled circuits.

3.2.6 Lifetime

The design shall take gradual degradation mechanisms and the predicted radiation environment (section 5.4) into account and show that the MEPED will perform within specifications during its first two (2) years in orbit. In addition, and except for the lowest energy proton and electron channel(s), (whose operation may be degraded or cease subsequent to the initial two year period), it shall be shown that the MEPED will operate within specifications for at least five (5) years in orbit. (ref. 5.5)

3.2.7 Size and Mass

a. The outside dimensions of the MEPED shall not exceed 252 mm long by 211 mm wide by 118 mm high. A design goal is that the length not exceed 202 mm.

b. The mass of the MEPED shall not exceed 4409 g.

3.2.8 Thermal

The SEM contractor shall specify any special operating thermal requirements of the design, e.g., special detector limitations, recommended operating ranges, etc.

3.2.9 High Voltage Protection

If voltages in excess of 100 V are used, the design shall show how the MEPED is internally designed and constructed to protect the MEPED itself, the interface with the DPU, and the interface with the rest of the spacecraft from damage due to the effects of possible high voltage breakdown.

3.2.10 Cable Length

The MEPED shall be capable of operation with cables up to 4600 mm (15 feet) in length between the MEPED and the DPU.

3.3 Data Processing Unit DPU

3.3.1 General

The DPU shall carry out all logic operations and accumulation necessary to meet the Technical Specification for the TED and MEPED which have not been carried out within the TED and MEPED themselves. It shall also contain an encoder for analog and digital telemetry. The only interface between the spacecraft and the SEM shall be through the DPU which shall route or concentrate all signals and power passing between the spacecraft and the SEM.

3.3.2 Data to the Spacecraft

a. The SEM, through the DPU, shall put out analog and digital signals to the spacecraft. The DPU shall provide digital data signals and digital housekeeping signals to the Digital "A". The DPU shall provide binary housekeeping signals to the spacecraft Digital "B". The DPU shall provide two (2) forms of analog information, Analog to the spacecraft Analog circuits and Digitized Analog to the spacecraft Digital "A".

b. To avoid changes to and to maintain compatibility with existing test and operational software, a design goal is that all telemetry provided by the SEM be as nearly identical as possible to the existing SEM format for the MEPED and TED. Telemetry allocated to the HEPAD, which is no longer required, (see Differences, section 1.5), may be reallocated. Possible assignments of signals appear in the table pp 47-51. These are presented for information only.

3.3.3 Digital "A"

a. The DPU shall put Status Bits for all states remembered in the SEM into the Digital "A" at least once every thirty two (32) seconds except that the TED Electron and Proton CEM HV PS Control bits may be telemetered in Digital "A" less often but shall be telemetered at least once every two hundred fifty six (256) seconds.

b. Bit assignments different from those now used (ref. 2.4) may be proposed for Digital "A" data if different signals are needed and the requirements of this specification are better achieved by such changed assignment. The HEPAD assignments may be so used.

c. An error-check word (possibly word 20 in minor frame 285) or words shall appear once in each major frame (32 s) in Digital "A" which shall check all SEM Digital "A" words 20 and 21 or a stated part of each Digital "A" major frame. Using this word in conjunction with the defined data and an algorithm, it shall be possible to determine unambiguously if any single bit error has occured and detect multiple-bit errors with a high probability.

3.3.4 Digital "B"

Digital "B" shall be used to send status monitors for command verification, to monitor certain key points within the SEM and to monitor correct operation of the SEM. Up to 20 single-bit, discrete monitors are available. These shall be sufficient to determine all command states within the SEM and the operation of any sequence controllers.

3.3.5 Analog Telemetry

3.3.5.1 Analog

a. The DPU shall provide some analog signals to the spacecraft as analog voltages in accord with the GIIS, in particular GIIS 3.1.6.3 and Table 7 sheet 58. These shall be sufficient to monitor operation of all power supplies, reference voltages and critical analog subsystems.

b. Telemetry points sufficient to permit evaluation of critical variables, including critical experiment temperatures, shall be provided. As this evaluation capability must be available at all times, it shall be provided by using the +28 Volt Analog Temperature Bus and be independent of whether the TED and/or MEPED are off.

c. Under failure conditions in the SEM, the analog functions shall not exceed the Over Range Limits in GIIS 3.1.6.3, Table 7. If any type of failure in the SEM could cause the analog inputs to exceed these limits, then protective clamping shall be provided.

3.3.5.2 Digitized Analog

The DPU shall digitize some analog signals, which shall be a subset of the Analog signals in 3.3.5.1, and provide them to the spacecraft in digital form in the Digital "A" data in accord with the GIIS, all as modified for this design.

3.3.6 Size and Mass

a. The outside dimensions of the DPU shall not exceed 305 mm long by 285 mm wide by 70 mm high.

b. The mass of the DPU shall not exceed 4300 g. A design goal is that the mass of the DPU not exceed 3100 g.

3.3.7 Commands

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3.3.7.1 Requirement

a. The DPU shall receive all commands sent to the SEM on 8 LEVEL command lines and 7 PULSE command lines. PULSE Command lines are also called STROBE lines. The SEM contractor shall define the commands.

b. One PULSE command line shall be assigned to turn the SEM off which shall turn the SEM off regardless of the state of any other line or the state of the SEM.

c. All possible commands shall be defined. "don't care" states shall be so defined. Conflicting commands shall cause no damage. Simultaneous TRUE and/or FALSE states or simultaneous changes on the command lines shall cause no damage.

d. A power "ON" command shall result in the safest "on" state.

e. The interaction between any possible command or sequence of commands and the state of the SEM shall be defined. In particular the relationship between IFC and TED or MEPED ON/OFF command and SEM state shall be defined. It is preferred, but not required, that if the TED or MEPED be turned off, that it not come back up in the IFC state when it is turned on again.

3.3.7.2 Information

a. For information, the commands presently used are listed here. To assist in ensuring compatibility with present operations this list includes Mnemonic and Hex Code which may not be significant for the SEM design.

	MNEMONIC	HEX CODE	NAME	LINE #	
PULSE COMMAND:	SEMDP	8444	SEM DPU STROBE	PC 1	
	SEMHD	8445	SEM HEPAD STRBE	PC 3	see
	SEMPS	8446	SEM PWR SW STRB	PC 4	below
	SEMTD	8447	SEM TED STROBE	PC 2	

LEVEL COMMAND:	SML1F	8249	SEM LINE 1 FALS
	SML1T	8149	SEM LINE 1 TRUE
	SML2F	824A	SEM LINE 2 FALS
	SML2T	814A	SEM LINE 2 TRUE
	SML3F	824B	SEM LINE 3 FALS
	SML3T	814B	SEM LINE 3 TRUE
	SML4F	824C	SEM LINE 4 FALS
	SML4T	814C	SEM LINE 4 TRUE
	SML5F	824D	SEM LINE 5 FALS
	SML5T	814E	SEM LINE 5 TRUE
	SML6F	824E	SEM LINE 6 FALS
	SML6T	814E	SEM LINE 6 TRUE

SML7T	814F	SEM LINE 7 TRUE
SML8F	8250	SEM LINE 8 FALS
SML8T	8150	SEM LINE 8 TRUE

b. Effect of commands

Effect of Pulse Command SEMDP
(also called PULSE COMMAND STROBE #1)
(also called PC #1)

if	then
SEM LINE 1 TRUE	Start TED IFC
SEM LINE 2 TRUE	Start MEPED IFC
SEM LINE 3 TRUE	don't care
SEM LINE 4 TRUE	Terminate IFC
SEM LINE 5 TRUE	don't care
SEM LINE 6 TRUE	don't care
SEM LINE 7 TRUE	don't care
SEM LINE 8 TRUE	don't care

Effect of Pulse Command SEMHD
(also called PULSE COMMAND STROBE #3)
(also called PC #3)
Available but not assigned.

Effect of Pulse Command SEMPS
(also called PULSE COMMAND STROBE #4)
(also called PC #4)

if	then
SEM LINE 1 TRUE	MEPED ON
SEM LINE 2 TRUE	MEPED OFF
SEM LINE 3 TRUE	TED ON
SEM LINE 4 TRUE	TED OFF
SEM LINE 5 TRUE	don't care
SEM LINE 6 TRUE	don't care
SEM LINE 7 TRUE	MAIN ON
SEM LINE 8 TRUE	MAIN OFF

Effect of Pulse Command SEMTD
(also called PULSE COMMAND STROBE #2)
(also called PC #2)

	if						then
SEM LINE	6	5	4	3	2	1	TED State
							binary
	1	L	M	0	0	0	Set 0 deg LEVEL LM = 00 to 11
	1	L	M	0	0	1	Set 30 deg LEVEL LM = 00 to 11
	x	x	x	0	1	x	don't care
	L	M	N	1	0	0	Set Proton HVPS LMN = 000 to 111
	L	M	N	1	0	1	Set Electron HVPS LMN = 000 to 111
	E	P	D	1	1	0	E TRUE = Electron HVPS ON
							E FALS = Electron HVPS OFF
							P TRUE = Proton HVPS ON
							P FALS = Proton HVPS OFF
							D TRUE = Deflection PS ON
							D FALS = Deflection PS OFF
	x	x	x	1	1	1	don't care

SEM LINEs 7 and 8 are both don't care.
1 = TRUE 0 = FALSE

3.4 General

3.4.1 The SEM shall be of simple, reliable design with one mode of operation for measurement and one form of IFC. Options for command voltages or scales shall be few.

3.4.2 Engineering Model

a. The Engineering Model shall be based on the detailed design adopted as a result of the Preliminary Design Review (PDR). Construction of the Engineering Model shall begin after the PDR. It shall be a fully functional unit, be identical to the intended Flight Model design, and shall incorporate all features and subsystems such as electronics, detector assemblies, etc. It shall use the same fabrication and workmanship techniques envisioned for the Protoflight Model. It shall incorporate parts and components of the same type as called for in the Protoflight Model, but they need not be Grade 1. Interfaces shall be the same as the for Protoflight Model.

b. The Engineering Model shall be used to verify engineering performance and must operate in accordance with the this Technical Specification SEL 86-1 for the Flight Model. It shall be used in the various tests specified in SEL 86-2 and also will be used for preliminary spacecraft interface testing.

c. Design changes to the Engineering Model are permissible insofar as required to correct deficiencies which may become apparent from testing and other sources.

3.4.3 Protoflight Model

The Protoflight Model shall be identical to the Flight Model. Its name comes from its intended use and not from how it is built. It shall be built using components identical to those in the the Flight Model. The Protoflight Model shall have passed qualification testing and calibration and then shall be delivered with all documents for flight on the protoflight spacecraft.

3.4.4 Flight Model

Each Flight Model shall have everything in final form including all documents. Each shall have passed acceptance testing and calibration before delivery.

3.4.5 Thermistors

a. Thermistors shall be interchangeable without recalibration. The circuit and thermistor tolerances shall be such that the uncertainty due to them shall be less than $\pm$ 1/2 LSB in the telemetry readout.

b. Calibrations for each type of thermistor circuit shall be calculated. The calculations shall include the self-heating effect of power dissipated in the thermistor. Thermistors to be telemetered as spacecraft analog data (not digitized in the SEM) shall be calibrated in volts versus temperature.

3.5 <u>Power System</u>

3.5.1 General

All SEM power supplies shall operate from the +28 Volt Main Bus.

3.5.2 Power

The power drawn by the SEM shall not exceed 13000 mW. A design goal is that the power not exceed 9600 mW. (ref. 7.2.6.2)

3.6 Electromagnetic Interference (EMI)
(also called Radio Frequency Interference [RFI])

The SEM shall be designed and packaged so that it is not adversely affected by interfering sources of RF energy and, conversely, must not be a source of interference which might adversely affect the operation of other satellite equipment. The SEM shall meet the RFI requirements specified in the GIIS 3.6.

3.7 Connectors

3.7.1 Test Points

To enable rapid fault isolation, separate test connectors shall be provided for signals within the SEM for use while the units comprising the SEM are under test on the bench or on the spacecraft. The separate test connector(s) shall include both input and internal bus monitoring points. While a test point is shorted the SEM shall operate within specification.

3.7.2 Separate Connectors

The SEM contractor shall provide separate connectors between the spacecraft and the interface with the SEM for the following inputs and outputs:

a. One connector for power and grounds.

b. One connector for all TIP signals, A_1, C_1, D_1 output, major frame sync pulse, etc.

c. One connector for Digital "B".

d. One connector for analog signals.

e. One connector for commands.

3.7.3 Mechanical

a. The shells of all external connectors shall be made from nonmagnetic material and shall have an electrically conductive finish. Cadmium plating shall not be used. Connector contacts shall be gold plated. Silver plating shall not be used under gold plating. Connectors shall be keyed, have different numbers of contacts and be of different types to prevent accidental mismating. On the chassis, male connectors shall be used for input power and input signals and female connectors shall be used for output power and output signals. Ten percent (10%) of the total number of contacts on each connector shall be spares.

b. Connector designations - Connector designations will be determined by the spacecraft contractor. Temporary designations may be used until such information is provided.

c. Connector marking - Each connector shall be marked with an identification number corresponding to the number shown on the electrical circuit diagrams. The marking shall be readily visible and shall contrast with the surface on which it is displayed.

3.7.4 Connector Savers

a. Connector savers shall be provided for each SEM Model and installed as soon as the Prototype Model and Flight Model units are assembled. The SEM ends of these savers shall conform to 3.7.3.

b. Connector savers are not for space flight use. They shall be used to limit the number of mate/demate cycles of the connectors on the SEM. Mates and demates on the flight connectors shall be limited to six (6) each and shall be recorded in the equipment log.

3.7.5 Spacecraft Cabling and Internal Interface

So that the cabling in the spacecraft to be provided by the spacecraft contractor may be made compatible with the SEM to be furnished by the SEM contractor, the SEM contractor shall furnish detailed information on the interface connectors. The information shall include connector type, pin assignment, and signal specification for each pin. The same information shall be furnished for interfaces within the SEM including any special requirements for the type of shields on the interconnecting cables.

3.8 <u>Mechanical</u>

3.8.1 Safety Factor

The load bearing mechanical components of the instrument shall be designed for a strength safety factor of at least two (2) considering the applicable qualification test requirements.

3.8.2 Gravity

Where the acceleration of gravity, g or G, is used its value shall be taken as that of standard gravity, 9.80665 m/s^2. In GIIS 3.7.3.3.4 the numbers shall be taken as multiples of g.

3.8.3 Screw Fastening

Self locking screws must be used to prevent loosening during environmental testing and launch. Where such screws are impractical, the use of approved locking epoxy is acceptable.

3.8.4 Cements and Epoxies

The use of cements and epoxies should be minimized. Only cements and epoxies meeting the requirements of section 3.8.8.3 may be employed. Mechanical backup shall be provided where cements or epoxies are used for the fastening of sensor or mechanical components.

3.8.5 Identification Name Plate, Serialization, and Marking

All SEM Model hardware shall be marked with the name of the unit, part number, serial number, and connector designations per MIL-STD-130F.

3.8.5.1 Name Plates

a. All deliverable hardware end items shall be permanently marked with a label of the following form (refer to GIIS 3.3.7):

INSTRUMENT: SEM/xxx
SERIAL NUMBER:
MODEL:
CONTRACTOR: Department of Commerce/NOAA/ERL/SEL
SUBCONTRACTOR:
SUBCONTRACTOR'S PART NUMBER:

where xxx = TED, MEPED, DPU, STC or BCU.

b. SERIAL NUMBER for each TED, MEPED and DPU shall start at 0009, that is the components of the Engineering Model shall be SERIAL NUMBER 0009.

c. MODEL shall be Engineering Model, Protoflight Model, or Flight Model (except GSE) marked as:

EM for the Engineering Model
PM for the Protoflight Model
FM-i for Flight Models where i is a sequence number.

Example: The second flight model will be MODEL FM-2 without leading zero's (and presumably consist of SERIAL NUMBERs 0012).

d. The SEM Contractor's firm name shall be entered opposite "Subcontractor."

3.8.5.2 Marking of Support Hardware, Cables, and Shipping Containers

All support hardware shall be marked or tagged to ensure against loss and to facilitate its usage. Test and patch cables shall be tagged, numbered and identified with the SEM hardware. The same applies to test equipment, shipping containers and miscellaneous test and support equipment.

3.8.6 Shipping Containers 2 sets required.

Reusable shipping containers shall be provided. The containers shall be designed (a) to protect the SEM, (b) to provide shock indication , (c) to allow inert gas packaging or purging and, (d) to be suitable for over-night air express shipment and for travel in highway vehicles.

3.8.7 Center of Mass

a. The design location of the center of mass of each component (TED, MEPED, DPU) shall be calculated to $\pm$ 2.5 mm and reported at the PDR.

b. The measured center of mass shall not be more than 5 mm from the location established at the CDR.

3.8.8 Materials

3.8.8.1 Fungus Resistance

The use of materials which are nutrient to fungus is not prohibited in hermetically sealed assemblies.

3.8.8.2 Corrosion of Metal Parts

Bare aluminum shall not be used.

3.8.8.3 Outgassing of Material

Materials shall not outgas, vaporize, or otherwise degenerate in a space environment in a manner and to a degree so as to interfere with the operation of spacecraft instruments, including particularly the SEM detectors. Each component shall be free from residual contaminants such as corrosion, inhibiting oils, greases, dyes and mechanical debris. (ref. PAR 6.2.4)

3.8.8.4 Material and Process List

At least forty five (45) days prior to the preliminary design review, the SEM contractor shall prepare and furnish a material and process list for the materials to be used in the SEM. The list shall categorize all materials listed as metals, plastics, coatings, miscellaneous, etc., and adequately identify the items by Government specification, process, cure cycle type, chemical composition and/or manufacturer. The list shall also specify the application(s) of each material in the SEM. The volume and surface area of each material shall be indicated using the code outlined below:

Volume		Surface Area	
Code	cm^3	Code	cm^2
A	0 to 1	1	0 to 1
B	1 to 50	2	1 to 100
C	50 to 100	3	100 plus
D	100 plus		

3.8.9 Finish

a. The external finishes applied to the SEM units shall satisfy the sensor and thermal requirements of the spacecraft and the SEM.

b. Exposed, insulated surfaces on parts of the SEM within 600 mm of the TED and on the TED itself shall not be used. (ref. 3.1.5.6)

3.8.10 Decomposition Products

The design shall avoid any adverse effects from combustion products (H_2, N_2, NH_3, H_2O) of the orbit and attitude adjust subsystem.

3.8.11 Venting

Venting of the SEM shall be sufficient to withstand the launch pressure profile and to allow the SEM to reach a pressure of 0.0013 Pa (10^{-5} torr) in 12 hours or less in a space environment. The venting shall provide a way for most gas to escape without passing near the apertures of the TED.

3.8.12 Maintainability

No special tools shall be required to remove the SEM from the spacecraft or to disassemble the SEM. Maintainability factors to be considered shall include:

1. Use of standard parts, tools, and test equipment.
2. Interchangeability. (ref. 3.4.5)
3. Minimizing the need for adjustments, alignments, and calibrations.
4. Fault detection and isolation techniques.
5. Fail safe design features.

3.8.13 Protective Covers

Protective covers, as specified in GIIS 3.2.11, shall be provided by the SEM contractor.

3.8.14 Magnetism

a. The design shall minimize susceptibility to magnetic fields.

b. The magnetic field produced by the SEM shall be less than 100 nT at a distance of one (1) metre from the SEM.

c. In the event that permanent magnets or magnetic materials present in the SEM interact with the spacecraft stabilization and control subsystem to the extent that the performance of that subsystem is adversely affected, suitable design changes shall be required of the SEM.

d. Neither the SEM, nor any of its component parts, shall be deliberately demagnetized for the purpose of reducing the magnetic field. In particular, do not do GIIS 3.5.3 .

3.9 Thermal

3.9.1 General

The performance of particle detector systems is often strongly dependent on correct thermal design of the detector assemblies to achieve optimum operating temperatures. The design shall give adequate consideration to the thermal requirements of the detectors.

3.9.2 Thermal Requirements

a. The TED and MEPED will be externally mounted, directly exposed to the space environment without protection by spacecraft structure and with minimum heat exchange to the spacecraft. The SEM shall operate in the space environment and meet all performance requirements with the SEM housing temperature cycling sinusoidally with a period of about 101.3 minutes.

b. If thermal couplings to the spacecraft are needed, these thermal couplings, both conducting and radiative, shall be computed. Any heat exchange with the spacecraft must be approved in writing by the COTR. If thermal control finishes or blankets are needed to control the instrument temperature, they shall be supplied by the SEM contractor.

c. Thermal conditions shall be calculated for the nominal orbit and for the launch phase, and extreme hot and cold cases. (ref. PAR 3.6.2)

d. Thermal interface drawings as specified in PAR Appendix E shall be supplied by the SEM contractor. As a minimum, they shall contain:

1. A view of all sides of the SEM including thermal control coating information such as surface material and surface absorptivity and emissivity.

2. Information regarding internal power distribution near each face to help determine whether any local hot spots exist.

3. a. If the SEM has its own louver control system: the size and location of the louver area and the total power ejected through this area.

b. If the SEM does not have its own louver control system: the area of the mounting feet, the heat flux density in watts per square metre through the mounting surface, and the direction in which the heat is flowing.

4. Special instructions for all things that have to be done to the instrument after assembly to the spacecraft such as special cleaning, insulating or closure requirements.

5. A power profile showing maximum and minimum power under all modes of operation.

3.9.3 Unpowered Flight

The SEM shall be designed to survive periods in orbit during which no power will be furnished to the SEM electronics. It must survive the temperature extremes predicted for this mode without degradation or failure. The SEM contractor shall provide such heaters as may be necessary for unpowered flight.

3.10 Special Handling of Detectors

a. Solid state detectors are degraded by exposure to extremes of temperature and can be destroyed by certain contaminants (such as ammonia fumes).

b. Channeltron particle detectors are sensitive to surface contamination. Materials which may cause degradation of channeltron performance by surface contamination shall not be used in the TED. Such materials shall not be used near the channeltrons during storage, neither before nor after assembly.

c. The SEM contractor shall submit a detailed plan covering the proposed procedures for the specification, qualification and acceptance testing, storage, and handling of the detectors.

4.0 GROUND SUPPORT EQUIPMENT (GSE)

4.1 General

a. The SEM Ground Support Equipment (GSE) shall include the unique equipment required to check, test, and calibrate the SEM at the SEM contractor's plant and later at a government facility and include the unique equipment required to check the SEM at the spacecraft contractor's plant.

b. The GSE shall provide two functions: a system test and a circuit test. Both shall use Radioactive Stimulus Equipment (RSE) (ref. 4.9).

c. The system test shall provide for operation of the SEM as would the spacecraft including providing all the power and commands and accepting of output as would the spacecraft. The system test shall provide computer capacity to receive, store and analyze the SEM output.

d. The circuit test shall provide tests to examine various signals and circuit points for use during design, construction, test, calibration, troubleshooting, and repair.

4.2 System Test Console 2 required

a. The SEM contractor shall supply a System Test Console (STC) to do the system test.

b. The STC shall be used by the SEM contractor for testing at the SEM contractor's plant. The Government intends to use the STC for receiving inspection tests of the SEM.

c. The STC shall provide all power, clock, TIP timing signals, commands and telemetry interfaces needed by the SEM which are normally supplied by the spacecraft.

d. The STC shall provide tests of all significant SEM voltages and signals at the spacecraft interface.

e. The STC shall provide complete operation of the SEM for determining if the units operate normally. This shall provide a go-no-go test in which a complete record of the test can be made on magnetic records.

f. The STC shall be used to do the tests in SEL 86-2 to determine and provide a record of the condition of the units.

4.3 Computer

a. The SEM contractor shall design and furnish automatic data processing equipment (herein called "computer") as part of the STC. As a minimum, the equipment must be able to generate self-test programs, command-sending programs, verification programs, limit checks, etc., and analyze the data and in-flight calibration sequences from the SEM. A minimum list of programs to be generated is specified in section 4.4. In addition to a CPU and memory, the STC shall contain at least the following equipment:

1. A means of writing data to removable magnetic media. Such media shall conform to one of the following industry standards:

   a. 9 track 1600 bpi phase encoded magnetic tape

   b. 40 track DS/DD 5 1/4" floppy disk in MSDOS 8/9 sector format.

2. All required digital and analog I/O interfaces.

3. Input keyboard and CRT display device.

4. Printer.

5. A calendar clock independent of local power.

6. At least 20 Mbytes of on-line storage.

7. A serial port for use in communicating with other computers.

b. The computer shall be able to analyze SEM data in near real time.

c. A continuous magnetic record of all data shall be made.

d. An output, when selected, shall be displayed in binary, hexadecimal or decimal form on a suitable visual display.

4.4 Software

4.4.1 General

The SEM contractor shall generate computer programs for use in the processing and interpretation of the test and calibration data. The programs shall be implemented via NOAA-approved software tools or utilities, or written in either the Pascal language or the C language. All source code, as well as the operating system and software necessary to run, maintain and modify such code (for example, an editor, a compiler), shall be supplied with the software. The programs generated are to be for the STC and its computer (ref 4.3) and, as a minimum, shall consist of the programs identified below.

4.4.2 SEM Operation Program

This program shall provide keyboard control of all SEM modes. If a display or print function is selected, SEM outputs shall be furnished in engineering units and the SEM status outputs shall be in English text.

4.4.3 History Program

Concurrent with 4.4.2, a history record shall be generated which shall contain all raw instrument output data and a header with the instrument number, date, time, test conditions, and any other pertinent information. Keyboard entry of nuclear calibration source data and other relevant comments shall be possible at the correct time on the history record. All raw data shall be contained on the history record.

4.4.4 History Analysis Program

This program shall enable all outputs required by 4.4.2 to be generated from a history record from the STC or from the Bench Check Unit (BCU) (ref. 4.5). The program shall analyze the history record and print out:

1. The flux in each energy spectral interval as computed by using the geometric factors and accumulation constants appropriate to the channel and test.

2. Summaries of all housekeeping data, converted to appropriate engineering units, with flags to indicate out-of-specified-limit conditions.

4.4.5 Utility Programs

Programs needed for maintenance of the GSE and SEM shall be provided along with other utility programs.

4.4.6 Access for Programming

Reasonable access to the GSE and SEM shall be allowed for additional program development by Government personnel.

4.5 Bench Check Unit 2 required

a. The SEM contractor shall supply a Bench Check Unit (BCU) to do the circuit test.

b. The BCU shall provide:

1. all power, control lines, clocks and signals to individually, independently test the TED, MEPED and DPU. Marginal conditions shall be included.

2. hardware breakout (i.e. switches or terminals) for use with standard laboratory instrumentation (not supplied as part of this contract) for monitoring any data or housekeeping line and for easy examination of signals on SEM lines and connectors.

c. Operation of an individual component of the SEM for troubleshooting shall be possible using the BCU to operate and control the individual component.

d. The BCU does not have to be capable of monitoring all outputs at the same time.

4.6 Detail

a. The GSE shall provide impedances, voltages and characteristics identical to those of the spacecraft and of the SEM circuits which the GSE simulates.

b. The GSE shall be compact, portable, easy to use, reliable and easily maintained.

c. Common laboratory test equipment such as a digital voltmeter, oscilloscope or counter may be used with the GSE. The SEM contractor shall not supply such equipment.

d. The GSE shall operate from 120 VAC at 60 Hz.

e. The design shall determine whether the STC and BCU require separate designs or whether they can and should be combined as one equipment.

f. The SEM contractor shall maintain the GSE, including its computers, throughout the contract.

g. The SEM contractor is encouraged to incorporate other desirable functions or capabilities into the GSE.

4.7 Check Plan

a. The SEM contractor shall develop the plan given in the proposal into a detailed check plan which shall provide complete functional tests of the SEM, both with and without the DPU. The plan shall be subject to approval by the Government and, when so approved, will be used for receiving tests of the SEM after delivery to the spacecraft contractor's plant.

b. The SEM contractor shall provide a written validation plan for the GSE to be used to show that the GSE itself functions.

4.8 Cables

The SEM contractor shall provide non-flight STC cables and non-flight BCU cables which, as required by the specified modes of operation of the STC and BCU, shall be capable of interconnecting the SEM itself, the SEM to the STC, the SEM to the BCU, and TED and MEPED to the STC and BCU.

4.9 Radioactive Stimulus Equipment (RSE)

a. Radioactive Stimulus Equipment (RSE) shall be provided which shall include the radioactive sources or other means necessary to provide as complete a test as is reasonably practical of the integrity of the various detectors used in the SEM when on the bench or on the spacecraft in ambient conditions or, where necessary, under vacuum.

b. The RSE will also be used for liveness tests at the SEM contractor's facility and at the spacecraft contractor's facility.

c. Additionally it may be used in incoming acceptance tests on the various Models (ref. 3.4) at the spacecraft contractor's facility.

d. The sources shall provide a SEM response sufficiently above background, either in the main data outputs or by oscillographic inspection at the instrument test connector, to assure that the detectors are undamaged, electrically connected, and biased.

e. So as to minimize the hazards to personnel involved in handling and transit, the sources shall be of the minimum strengths necessary to perform their functions over the period of the contract. At the option of the contractor, shorter lifetime sources which are periodically replaced may be employed.

f. The SEM contractor shall meet all federal and state requirements for handling, storage and disposal of radioactive materials.

4.10 Vibration Fixture

All vibration fixture(s) needed to mount the SEM (all modes) during vibration tests shall be furnished by the SEM contractor.

Connector [illegible]

3.7.4
1-24

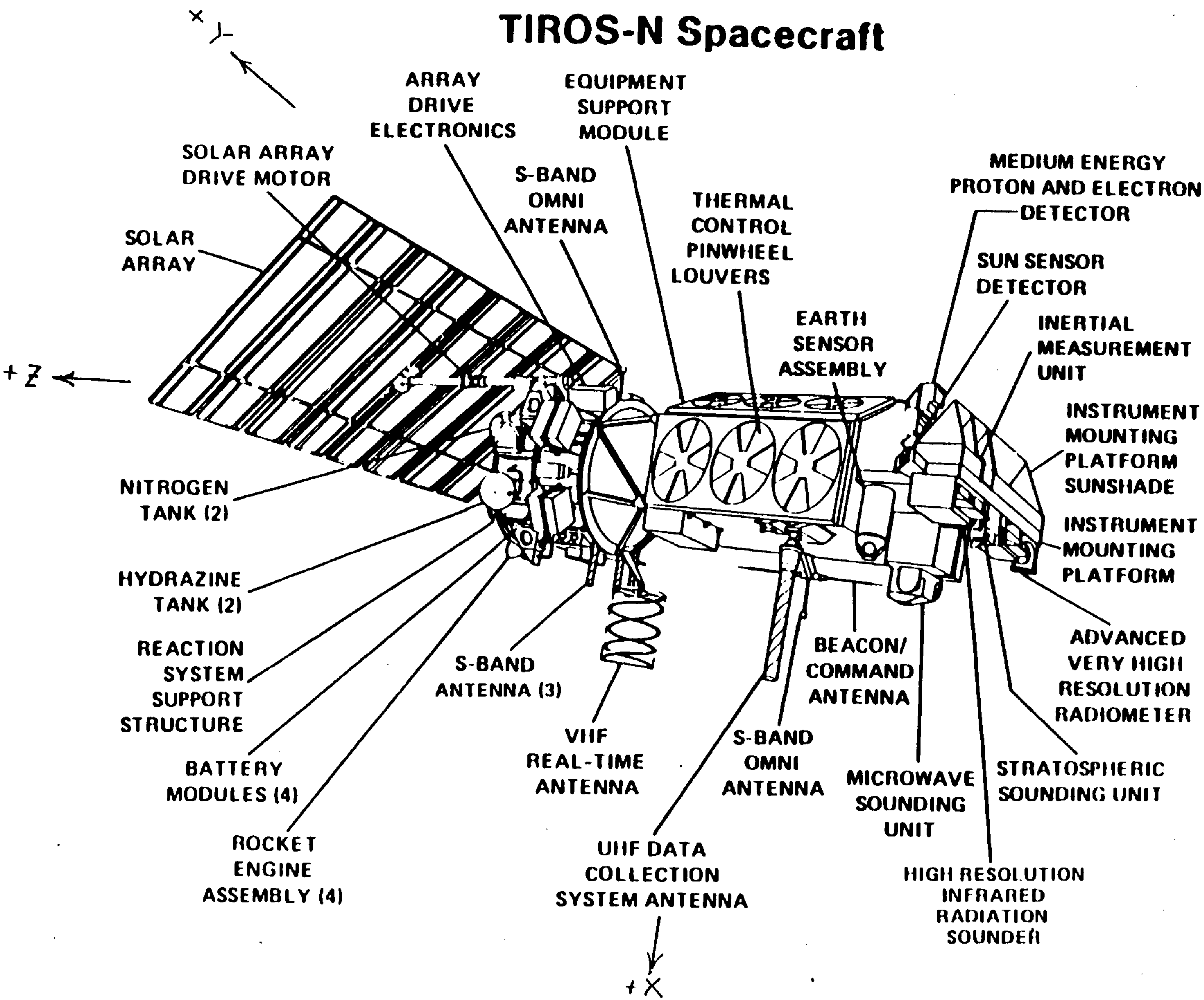
4.11 Mounting Hole Templates

The SEM contractor shall fabricate two (2) sets of mounting hole templates for locating holes for mounting the SEM on the spacecraft. One will be retained by the SEM contractor and the second will be transferred to the spacecraft contractor along with drawings and design information for the jigs. (ref. GIIS 3.2.12.1)

4.12 Demonstration of GSE

Satisfactory operation of the Ground Support Equipment including the validation plan (ref. 4.7 b.) shall be demonstrated during testing of the Engineering Model. Checkout testing of the GSE shall be the responsibility of the SEM contractor.

TIROS-N Spacecraft



5.0 OPERATION

5.1 Orbit

a. Orbit altitude - 450 ± 50 n mi (833 ± 93 km) circular

b. Orbit period - approximately 101.3 minutes

c. Longitude shift - 25.3 degrees per orbit

d. Inclination - 98.7 degrees sun-synchronous

e. 12:40 to 18:00, local time, ascending node or 06:00 to 11:20, descending node

5.2 General Arrangement of the Spacecraft

Figure 1 shows the general arrangement of the TIROS-N spacecraft and its coordinate system. The current mounting position for the SEM is shown.

5.3 Operational Schedule

The SEM shall be able to operate continuously.

5.4 Space Radiation

a. The expected radiation environment shall be taken as that given in Performance Specification for the NOAA-H through -J Satellites, GSFC-S-480-16B 3.2.5.1 c. on p. 19 . (Amend 2)

b. The uncertainty in the trapped particle data is about a factor of 3 for electrons and a factor of 2 for protons. Since vehicle launch (now tentatively planned for 1992) falls into the next period of maximum solar activity, the occurrence of energetic solar proton fluxes is to be expected. The exposure to these particles of satellites with circular polar trajectories in the altitude h range of 600 to 1000 km is virtually independent of h. For the TIROS-N orbit, the exposure factor is about 30%.

5.5 Operating and Storage Life

The SEM shall be designed to provide continuous orbital operation for a period of at least two (2) years after ninety (90) days continuous operation at the spacecraft contractor's facility prior to launch. As there may be significant delays between delivery and launch dates, storage of the SEM for periods of up to three (3) years shall not degrade its performance. (ref. 3.1.9, 3.2.6)

5.6 Relative Humidity

The SEM shall be designed to withstand exposure to a relative humidity of 95% at 30 deg C for 24 hours without degradation of performance. Exceptions as may be required for detectors shall be reported.

6.0 TECHNICAL SUPPORT

6.1 Spares

The SEM contractor shall provide the spares likely to be required to maintain the SEM's according to the reliability study of SEL 86-2 section 7.3.1, delivering or using them for repair during the contract and delivering the remainder at completion of the contract.

6.2 Delivery and Integration

The SEM contractor shall provide the services of one (1) person to deliver each SEM and to provide the spacecraft contractor with technical support and assistance during tests of the SEM. This service is expected to require two separate trips and fifteen (15) man days of effort for each model. (Work under this 6.2 is not part of Field Support 6.4.)

6.3 Repair

Until completion of the contract the SEM contractor shall maintain and repair all hardware and software delivered under this procurement including, until launch, all SEM space flight hardware.

6.4 Field Support

When requested, the SEM contractor shall do troubleshooting and work to resolve nonconformances and anomalies. When requested, the SEM contractor shall do operation and analysis work with respect to in-flight use of the SEM and SEM data.

7.0 DOCUMENTS AND REPORTS

7.1 General

a. So that the Government will be assured that requirements of the contract will be met, coordinate its own schedules and monitor progress of the contract, the SEM contractor shall furnish data, drawings, plans and periodic reports throughout the contract performance period. The items of interest in order are:

Design
Quality
In-flight performance
Schedule
Cost.

This section provides guidance to the SEM contractor as to the nature and extent of the documents and reports which shall be furnished and, to some extent, recapitulates requirements contained in other portions of the contract. While substantially all of the required documentation and reports are listed in this section, the list is not all inclusive and any other document(s) and report(s) required by any other part of the contract shall be furnished by the SEM contractor.

b. All technical memoranda, documents and reports submitted for review shall be submitted to the COTR in triplicate immediately after preparation.

c. Drawings, plans, and specifications subject to review and approval by the COTR will be returned, either approved or disapproved, within two (2) weeks from the date of their receipt. If approval is withheld because changes or corrections to the document(s) are necessary, the SEM contractor shall make the changes/corrections and resubmit the document(s) to the COTR within ten (10) days (or such longer period as may be authorized by the Contracting Officer) from the date the need for change or correction is made known.

d. Technical data related to this program, but not specifically required herein, shall be made available upon request by the Contracting Officer.

e. As soon as practicable after award, the spacecraft contractor will prepare and furnish interface control documentation for the SEM. This documentation will be jointly reviewed by the spacecraft contractor, the SEM contractor, and the Government.

7.2 Design Documents

7.2.1 Preproduction Designs and Specifications

Design and inspection specifications and/or drawings shall be prepared for each different assembly. Before beginning production and assembly all specifications and drawings shall be submitted for review and approval by the COTR.

7.2.2 Preliminary Drawings or Engineering Sketches

As preliminary drawings and sketches of the type described by section 7.2.3.2 b. below are prepared, one copy of each shall be furnished to the COTR. Because these copies are for information only, they need not be reproducible and approval of their content is not required.

7.2.3 Technical Drawing

7.2.3.1 Format

All assembly and detailed drawings shall be prepared in accordance with DOD-STD-100C.

7.2.3.2 Released Drawings

a. All drawings or sketches released for procurement or fabrication shall be prepared by professional draftsmen. One (1) reproducible and two (2) copies of each such drawing or sketch shall be furnished with the quarterly progress report following their production. Except for printed wiring masters, printed wiring drilling drawings, weldment drawings and casting drawings, all drawings and sketches shall be furnished.

b. Types of drawings which shall be submitted shall include, but not be limited to:

a. All drawings required to define the interfaces with the spacecraft and the test facilities;

b. Wiring diagrams, schematics, and logic diagrams for instrument and test equipment;

c. Mechanical configuration drawings;

d. Complete lists of drawings for both the SEM models and the deliverable test equipment;

e. General Assembly drawings; and

f. Revisions to any drawing previously submitted.

c. All drawings not specifically required herein, but which are required for the fabrication of the SEM, and the drawings excepted in section 7.2.3.2 a. above shall be made available to the Government upon request by the Contracting Officer.

7.2.4 Drawing Changes/Revisions

Subsequent to their approval by the COTR, drawings shall not be changed or revised except as requested or approved by the Government. The SEM contractor shall furnish one (1) reproducible copy of each Engineering Change Request (ECR). Drawing changes shall be based on an ECR prepared by the SEM contractor's engineering staff and approved by the COTR. After approval, the ECR document, together with the changed drawing, shall be furnished with the next weekly report.

7.2.5 Cable Requirements

Cable requirements shall be submitted by the SEM contractor as a part of the second quarterly progress report. Schematic drawings illustrating cable routes shall be furnished with the fourth quarterly report.

7.2.6 Interface Budgets

7.2.6.1 Mass Budget

The SEM contractor shall maintain a mass budget listing the mass and center of mass of each subassembly (including mounting hardware) and specifying whether each mass is estimated, calculated, or measured. This shall be supplied with each quarterly report after the Preliminary Design Review. Updating of the mass budget shall be reported monthly in one of the weekly reports.

7.2.6.2 Power Budget

The SEM contractor shall maintain a power budget listing the power of each major module, variations during life and end-of-life values and specifying whether each is estimated, calculated, or measured. This shall be reported in each quarterly report. (ref. 3.5.2)

7.2.7 Material and Process List

The SEM contractor shall prepare and furnish a material and process list as required in 3.8.8.4. The initial list shall be furnished at least forty five (45) days prior to the Preliminary Design Review and then updated in each quarterly report.

7.2.8 Engineering Analysis Reports

7.2.8.1 General

a. The SEM contractor shall provide analysis reports to verify the design work. The reports shall contain both the pertinent analyses performed during the design effort and any additional analyses required to satisfy the reporting requirements of this section 7. All analyses shall include but not be restricted to worst case conditions.

b. The analysis reports shall be prepared in preliminary form and submitted at least twenty (20) days prior to the Preliminary Design Review. A final report shall be submitted at least one (1) month prior to the Protoflight PreShipment Review.

7.2.8.2 Sensor Design Analysis

a. The sensor design analysis report shall contain all analysis, including the physics of the sensors, performed to confirm the design of the sensor assemblies. It shall include, but not be limited to, the calculation of nuclear shielding effectiveness, energy deposition versus incident energy for all detectors and computation of sensor geometric factors. (Ref. 3.10, PAR 3.3.1.1)

b. The SEM contractor shall report the optimum operating temperature for the detectors and detector assemblies.

7.2.8.3 Electronic Analysis

a. The electronic analysis report shall contain AC and DC nominal and worst case analysis.

b. Circuits utilizing feedback shall be analyzed for stability margins using gain phase response measurements and calculations. The worst case end points shall include the manufacturer's stated tolerance, power supply variation, and temperature variation in determining probable effects.

c. All channel elements shall be analyzed for contribution to system noise and a noise contribution budget for each channel shall be prepared.

7.2.8.4 Mechanical Analysis

a. The mechanical analysis report shall contain detailed stress and flexure calculations to show that the design is adequate to survive the vibration testing. Also, the report shall show that the accuracy of the experiment and the external and/or interface dimensions will be maintained through vibration, acceleration, and thermal cycling tests. A safety factor of at least two (2) shall be demonstrated for all critical components.
b. The preliminary report (ref. 7.2.8.1 b.) shall include a calculation of the center of mass and moments of inertia about three (3) axes, for each box (ref. 3.8.7). The final report shall show the measured location of the center of mass.

7.2.8.5 Thermal Analysis

The thermal analysis report shall comply with PAR 3.6.2.

7.2.8.6 Reliability Calculation

The SEM contractor shall report the reliability calculation required in SEL 86-2.

7.2.8.7 Failure Mode Effect and Criticality Analysis

The SEM contractor shall report the failure mode effect and criticality analysis required in SEL 86-2.

7.2.9 Monitors

The SEM contractor shall submit recommendations for the command, housekeeping, and status monitors at least forty five (45) days prior to the Preliminary Design Review.

7.2.10 Data Output Format

The SEM contractor shall provide the final data output format compatible with 3.3 and the GIIS at least forty five (45) days prior to the Preliminary Design Review.

7.2.11 Design Report

The SEM contractor shall produce a final design report which, in combination with the SEM and GSE Instruction Manuals, shall be a complete, stand-alone, technical description of the SEM, including detailed theory of operation of sensors and circuits.

7.3 Instruction Manuals

The SEM contractor shall provide brief and concise instruction manuals for SEM models and for the GSE as specified below. One (1) reproducible master and ten (10) copies are required prior to or with delivery of the first of each model.

7.3.1 SEM Instruction Manuals

A complete set of instruction manuals shall be delivered concurrently with the Protoflight Model. The manuals shall be updated throughout the contract and, at a minimum, contain:

a. A brief summary description of the SEM.

b. A description of the SEM.

c. SEM operation procedures.

d. Special instruction and procedures.

e. SEM maintenance procedures.

f. Mechanical assembly diagrams and procedures.

g. Bench checkout procedures (may be furnished as a separate document.)

h. Parts list.

i. Interfaces with the NOAA-K, -L, -M spacecraft.

j. A complete and up-to-date set of schematics, logic and signal flow diagrams. Mechanical drawings shall be included as composite, numbered pages of the manuals. Reductions shall follow 7.3.3 .

7.3.2 STC and BCU Instruction Manuals

The SEM contractor shall prepare instruction manuals which describe the capabilities, operation, and installation of the BCU and the STC. A complete and up-to-date set of drawings shall be included. All schematics, diagrams, and drawings shall be included as composite numbered pages of the manuals. Reductions shall follow 7.3.3 . If commercial data processing equipment or software is included then this requirement shall be satisfied by a full set of the manufacturer's relevant technical and operation manuals.

7.3.3 Drawing Reduction

If reduction is necessary, schematics, diagrams, and drawings shall be photographed before reduction to the following size:

1) Height: Equal to that of the text pages

2) Width: Equal to that of the text pages, or a multiple thereof, with foldaway. 90-1-10

7.4 Check Plan

The Check Plan of 4.7 shall be prepared by the SEM contractor after consultation with the COTR. It shall be submitted to the COTR for review at least forty five (45) days prior to its initial use.

7.5 Photographs

7.5.1 General

The SEM contractor shall provide photographs of the SEM, its assemblies, and ground support equipment. The SEM contractor shall furnish a 35 mm slide and four 8 x 10 inch glossy prints of each photograph. All photographs shall be in color and shall include a metric scale.

7.5.2 SEM Photographs

A minimum of six (6) views illustrating each unit in the Protoflight SEM are required. These shall show the SEM both in final form and partially disassembled. Separate photographs shall be staged, show as many details as practical, and show the relationships of the various assemblies.

7.5.3 GSE Photographs

These photographs shall be staged to aid in planning the installation and use of the GSE.

7.6 Management Documents

7.6.1 Project Organization Chart

The SEM contractor shall provide a detailed project organization chart showing the assignments of key personnel such as the project manager, mechanical and electronic engineers, and quality/reliability personnel. This chart shall be maintained and updated throughout the contract as part of PAR 1.6 b.

7.6.2 Project Plan

Within thirty (30) days after contract award, the project plan submitted as a part of the SEM contractor's proposal shall be refined by adding a work breakdown structure and a cumulative expenditure curve. The SEM contractor shall prepare the Work Breakdown Structure (WBS) through level III (ref. Handbook for Preparation and Implementation of Work Breakdown Structure GHB7120.1). The WBS shall be updated throughout the contract.

7.6.3 Work Plan

The work plan submitted as a part of the SEM contractor's proposal shall be routinely updated and reported monthly in one of the weekly reports. The work plan shall provide for PERT and critical path information to allow control of the work, to allow adjustments and to allow knowing the effect of adjustments.

7.6.4 Performance Schedule Reports

a. So that the Government may be provided with the detail necessary to monitor progress under the contract, the SEM contractor shall establish and maintain a schedule control system in conjunction with the WBS. The schedule control system shall identify and describe in a performance schedule the sequence of the required work, shall show how development, manufacture, and assembly of interdependent items will be coordinated and controlled and shall establish separate and definitive milestones which must be met to assure that each delivery will be made as required by the contract. The format shall be in accordance with the WBS. The system shall integrate with the SEM contractor's internal control system and the schedule shall be detailed enough to include printed circuit boards and parts of each major subassembly (excluding standard electronic piece parts).

b. The performance schedule shall be submitted to the COTR within thirty (30) days from the date of contract award, shall be a subject in the weekly reports and shall be updated in each monthly report.

c. Reports on the performance schedule shall identify each separate event and, for each event, shall include:

1. The originally planned starting date;
2. The actual starting date;
3. The originally planned completion date; and
4. The current completion estimate or the actual completion date, as appropriate.

7.6.4.1 Monthly Management Report

Each Monthly Management Report shall revise and update each appropriate schedule to show the planned progress through the estimated delivery dates of units. This report shall be delivered with the Monthly Status Report 7.6.6.

7.6.4.2 Weekly Management Report

Weekly Management Reports shall include the current status of each active task (defined in the WBS) and shall identify those tasks which will be accomplished or worked on during the ensuing week. Any changed schedule or actual event shall be reported in the Weekly Management Report.

7.6.5 Weekly Status Report

a. Weekly Status Reports shall be made for the purpose of giving timely information so that suitable coordination, action, advice and decisions may be provided.

b. Via telephone or direct text file transfer to a SEL computer, the SEM contractor shall report the status of the contract to the COTR. The following information shall be reported to the COTR each Tuesday.

1. Technical progress including significant accomplishments and milestones (defined in the WBS) reached.

2. Problems and proposed correction actions.

3. Anticipated program slippages and their effects.

4. Performance schedule status report.

5. Status of malfunction reports.

6. Mass and power budget changes.

7. Other items.

7.6.6 Monthly Status Report

a. The SEM contractor shall submit three (3) copies of a Monthly Status Report for each month. The report is due within ten (10) days after each month ends. The report shall, as a minimum, include the following:

1. Review of work performed during the month

2. Review of design decisions and interface matters

3. Analysis performed during the month

4. Mass budget

5. Power budget

6. Materials and parts list status

7. Request for Government approval or coordination required during subsequent quarter

8. Current drawing status

9. Test and calibration results as available

10. Malfunction report status

11. Revised schedule(s).

b. Unless otherwise specified, all work shall be reported in at least one of the Monthly Status Reports. The Monthly Status Reports shall constitute the complete record of activity under the contract.

c. A copy of the Monthly Status Report shall be submitted to the TIROS-N Instrument Manager, Code 480, Goddard Space Flight Center concurrently with transmittal to the COTR.

d. Monthly reports may be submitted with the monthly Performance Assurance reports (ref. PAR 1.6 b.).

7.6.7 Financial Report

The SEM contractor shall submit a quarterly financial report on NASA Form 533 which will provide a summary of total costs incurred to date and estimates of the total costs expected to be incurred in the ensuing quarter and for the balance of the Government fiscal year. For the third and fourth quarters of the fiscal year, the report shall also include an estimate of costs expected to be incurred in the following fiscal year. The report shall contain the cumulative expenditure curve required under section 7.6.2 with the actual cumulative expenditure and any new forecast of future cumulative expenditure superimposed.

7.6.8 Quarterly Documentation

a. Material, Process and Part Lists. Following their initial submission, these lists shall be updated at least quarterly and resubmitted if changed.

b. Current Drawings. A package of released drawings shall be submitted quarterly, including all such drawings either originated or revised during the preceding quarter.

SEM Digital A Telemeter Signals

The following 4 pages list draft assignments of digital A signals which are suitably compatible with current usage.

These assignments are not the only possible assignments. They are presented for information only.

(The 4 pages can be assembled into a rectangular chart.)

DIGA Telemeter Data by Minor Frame Number 87-1-16
Space Environment Monitor DRAFT ASSIGNMENTS

0	20	40	60	80	100	120	140
*DPU	*MEP E	MEP P	MEP	MEP	MEP P	MEP E	DPU
12V	Bias	Bias	Omni T	El T	Tel T	Tel T	T
0P1	-	-	-	-	-	-	-
1	21	41	61	81	101	121	141
0P2	-	-	-	-	-	-	-
0P3	-	-	-	-	-	-	-
2	22	42	62	82	102	122	142
0P4	-	-	-	-	-	-	-
0P5	-	-	-	-	-	-	-
3	23	43	63	83	103	123	143
0E1	-	-	-	-	-	-	-
0E2	-	-	-	-	-	-	-
4	24	44	64	84	104	124	144
0E3	-	-	-	-	-	-	-
0P6	-	-	-	-	-	-	-
5	25	45	65	85	105	125	145
0DE3	3DE3	0DP3	3DP3	0DE3	3DE3	0DP3	3DP3
*0EFL	-	-	-	-	-	-	-
6	26	46	66	86	106	126	146
0DE5	3DE5	0DP5	3DP5	0DE5	3DE5	0DP5	3DP5
*3EFL	-	-	-	-	-	-	-
7	27	47	67	87	107	127	147
0DE7	3DE7	0DP7	3DP7	0DE7	3DE7	0DP7	3DP7
*0PFL	-	-	-	-	-	-	-
8	28	48	68	88	108	128	148
0DE9	3DE9	0DP9	3DP9	0DE9	3DE9	0DP9	3DP9
)3PFL	-	-	-	-	-	-	-
9	29	49	69	89	109	129	149
9P6	*-	-	-	-	-	-	-
0EM 0PM	- -	- -	- -	- -	- -	- -	- -
10	30	50	70	90	110	130	150
3EM 3PM	- -	- -	- -	- -	- -	- -	- -
9P1	-	-	-	-	-	-	-
11	31	51	71	91	111	131	151
9P2	-	-	-	-	-	-	-
9P3	-	-	-	-	-	-	-

87-1-16

12	32	51	72	92	112	132	152
9P4	-	-	-	-	-	-	-
9P5	-	-	-	-	-	-	-
13	33	53	73	93	113	133	153
9E1	-	-	-	-	-	-	-
9E2	-	-	-	-	-	-	-
14	34	54	74	94	114	134	154
9E3	-	-	-	-	-	-	-
P6	-	-	-	-	-	-	-
15	35	55	75	95	115	135	155
P7	-	-	-	-	-	-	-
P8	P9	P8	P9	P8	P9	P8	P9
16	36	56	76	96	116	136	156
0EFD	-	-	-	-	-	-	-
0PFD	-	-	-	-	-	-	-
17	37	57	77	97	117	137	157
3EFD	-	-	-	-	-	-	-
3PFD	-	-	-	-	-	-	-
18	38	58	78	98	118	138	158
0DEM	-	-	-	-	-	-	-
0DPM	-	-	-	-	-	-	-
19	39	59	79	99	119	139	159
3DEM	-	-	-	-	-	-	-
3DPM	-	-	-	-	-	-	-

2 s 4 s 8 s 16 s

MEPED Code abc

a = 0, 9 for 0 and 90 degrees
b = E, P for electrons and protons
c = 1 to 3 for electron energy
1 to 6 for proton energy

aE1	aE2	aE3
30	100	300 keV

aP1	aP2	aP3	aP4	aP5	aP6
30	80	250	800	2500	7000 keV

if a is missing: b = P

P6	P7	P8	P9
16	35	70	140 MeV

Energy numbers are the low ends of the ranges.
The list here does not indicate which signals are for a finite range and which are integral.

160	180	200	220	240	260	280	300
*DCB	*PC 1-4	*TED	TED E	TED P	TED	*0EBK	*3EBK
1-8	+bits	bits	ch PS	ch PS	T		
0P1	-	-	-	-	-	-	-
161	181	201	221	241	261	281	301
0P2	-	-	-	-	-	-	-
0P3	-	-	-	-	-	-	-
162	182	202	222	242	262	282	302
0P4	-	-	-	-	-	-	-
0P5	-	-	-	-	-	-	-
163	183	203	223	243	263	283	303
0E1	-	-	-	-	-	-	-
0E2	-	-	-	-	-	-	-
164	184	204	224	244	264	284	304
0E3	-	-	-	-	-	-	-
0P6	-	-	-	-	-	-	-
165	185	205	225	245	265	285	305
0DE3	3DE3	0DP3	3DP3	*0DE3	*3DE3	*spare	sync f3
*0EFL	-	-	-	-	-	-	-
166	186	206	226	246	266	286	306
0DE5	3DE5	0DP5	3DP5	*0DE5	*3DE5	*TED	sync 50
						ramp	
*3EFL	-	-	-	-	-	-	-
167	187	207	227	247	267	287	307
0DE7	3DE7	0DP7	3DP7	*0DE7	*3DE7	*0PBK	*3PBK
*0PFL	-	-	-	-	-	-	-
168	188	208	228	248	268	288	308
0DE9	3DE9	0DP9	3DP9	*0DE9	*3DE9	TED	DPU
						CEAPS	ramp
3PFL	-	-	-	-	-	-	-
169	189	209	229	249	269	289	309
9P6	-	-	-	-	-	-	-
0EM 0PM	- -	- -	- -	- -	- -	- -	- -
170	190	210	230	250	270	290	310
3EM 3PM	- -	- -	- -	- -	- -	- -	- -
9P1	-	-	-	-	-	-	-
171	191	211	231	251	271	291	311
9P2	-	-	-	-	-	-	-
9P3	-	-	-	-	-	-	-

							87-1-16
172	192	212	232	252	272	292	312
9P4	-	-	-	-	-	-	-
9P5	-	-	-	-	-	-	
173	193	213	233	253	273	293	313
9E1	-	-	-	-	-	-	-
9E2	-	-	-	-	-	-	-
174	194	214	234	254	274	294	314
9E3	-	-	-	-	-	-	-
P6	-	-	-	-	-	-	-
175	195	215	235	255	275	295	315
P7	-	-	-	-	-	-	-
P8	*P9	P8	*P9	P8	*P9	P8	*P9
176							
0EFD							
0PFD							
177							
3EFD							
3PFD							
			all same as at left				
178							
0DEM							
0PDM							
179	199	219	239	259	279	299	319
3DEM							
3DPM							
				24 s			32 s

* New assignment different from NOAA-G.
Minor frames used here but not used in NOAA-G
are ~~[illegible]~~ marked.)

xxx	minor frame number	
yyyy	data in word 20	- means same as at left.
zzzz	data in word 21	Where data have two codes:
		4 bits are used by each (frame 9, 10).

TED code abc

a = 0, 3 for 0 and 30 degrees

in b E = electrons

P = protons

In TED codes E and P do not appear alone.

Technical Specification TED Item 1 = aEFD, aPFD

Item 2 = aEFL, aPFL

Item 3 = aDEM, aDPM

Item 4 = aEM, aPM

Item 5 = aDEc, aDPc c = 3, 5, 7, 9

Item 6 = aEBK, aPBK

Acromyns and Letter Groups

A/D	analog to digital
BCU	bench check unit
CDR	critical design review
COTR	Contracting Officer's Technical Representative
CRT	cathode ray tube
DPU	Data Processing Unit
DS/DD	double sided, double density
ECR	engineering change request
EM	Engineering Model
EMI	electromagnetic interference
ERL	Environmental Research Laboratory
FM	Flight Model
FMECA	failure mode effect and criticality analysis
FWHM	full width half maximum
GIIS	General Instrument Interface Specification
GSE	Ground Support Equipment
GSFC	Goddard Space Flight Center
HEPAD	High Energy Proton and Alpha Detector
IFC	in-flight calibration
LSB	least-significant bit
MEPED	medium energy proton and electron detector
NASA	National Aeronautics and Space Administration
NHB	NASA Handbook
NOAA	National Oceanic and Atmospheric Administration
nT	nanotesla SI unit of magnetic field strength
Pa	pascal SI unit of pressure
PAR	Performance Assurance Requirements SEL 86-2
PDR	preliminary design review
PERT	program evaluation and review technique
PM	Protoflight Model
PPL	preferred parts list
SEL	Space Environment Laboratory
SEM	Space Environment Monitor
SI	International System of Units
STC	System Test Console
RFI	radio frequency interference
rms	root mean square
RSE	Radioactive Stimulus Equipment
TED	Total Energy Detector
TIP	TIROS Information Processor
TIROS	Generic name for a series of polar weather satellites infrared orbiting satellite
torr	unit of pressure 1 mm Hg approx. 133.3 Pa
WBS	work breakdown structure

End of Technical Specification SEL 86-1